## Stopping Erosion With Gypsum and PAM

n the late 1700s, Benjamin Franklin, whose interest in scientific experiments is now legend, demonstrated the value of a natural geological substance called gypsum, used in making plaster, as a soil amendment.

On a prominent hillside, Franklin applied gypsum in a word pattern that read, "This land has been plastered." The increased grass growth in the area on which the gypsum had been applied served as an effective demonstration of its value as a fertilizer.

Two hundred years later, gypsum is again being studied—this time as a way of controlling erosion by increasing water infiltration.

"New technologies to improve air quality have produced more and more gypsum byproducts with potential for beneficial use in agriculture," says ARS soil scientist L. Darrell Norton. He is at the National Soil Erosion Research Laboratory (NSERL) in West Lafayette, Indiana. "The removal of sulfur from flue gases in coal-fired power plants has resulted in immense stockpiles of these byproducts that can supply sulfur to crops and may also serve as a liming agent."

"Each year, power plants produce about 100 million tons of gypsiferous material, high in calcium and sulfur, as a byproduct of capturing sulfur dioxide emissions," says W. Doral Kemper, who formerly led the ARS national program in soil management research. "That's enough to apply a ton per acre to a quarter of U.S. farmland."

Norton and Kemper believe that recycling these low-cost byproducts of industry to control erosion and increase yield is a win-win situation. They say gypsum can be used on many soils nationwide to improve water infiltration and help plant growth.

The two believe the increased yields are explained by studies conducted by ARS soil scientists K. Dale Ritchey at Beaver, West Virginia, and Ronald F. Korcak at Beltsville, Maryland, and their coworkers. These studies have shown that calcium from gypsum applied to acidic soils gets down into the subsoil where it is needed, so crop roots can grow deeper and access more water.

Norton says, "Using gypsiferous byproducts would give farmers a low-cost remedy for acid, sodic, and erosion-prone soils."

KEITH WELLER (K7755-2)



Soil scientist Darrell Norton (left) and Ralph Woodward, a cooperating corn farmer, assess the effect of field application of gypsum on plant root growth.

Several years ago, ARS scientists at the NSERL worked with world-renowned soil scientist Isaac Shainberg, who is now director of the Volcani Institute in Israel. They wanted to determine how electrolytes, which are natural electrical conductors in rainfall and runoff water, could affect estimates of soil erodibility. During Shainberg's visit, the idea of using gypsum and other soil amendments to control soil erosion by water from agricultural fields was also discussed.

"We suspected that gypsum could reduce surface sealing and improve water entry and reduce erosion," says Norton. "In lab studies, we found the powdered waste product releases electrolytes that keep clay particles clumped together, reducing crusting."

About the same time, Shainberg became interested in another white powder—PAM, short for polyacrylamide—a material used in water treatment plants as a flocculent to clean up the water by precipitating small particles.

"According to the literature, you could stabilize a soil with PAM, but it was very expensive for practical use

when mixed in the entire plowed layer," says Norton. A series of lab studies conducted by Shainberg and ARS scientists on some small flumes confirmed that as little as 5 to 10 parts per million of PAM mixed with water almost eliminated rill erosion—the tiny gullies caused by water moving over the soil.

At the NSERL, Norton and Shainberg, working with three ARS colleagues—soil microbiologist Diane E. Stott, agricultural engineer John M. Laflen, and soil scientist Joe M. Bradford—studied how adding PAM both to simulated

rainfall water and to the soil surface affected erosion. They soon came to recognize that if the soil surface could be stabilized down to just a very small depth, erosion might be greatly reduced.

"Most important," says Norton,
"was the finding that PAM didn't have
to be mixed into the soil. Only the surface layer—less than the top one-sixteenth inch or less of soil—has to be
treated, to let water into the soil."

NSERL agricultural engineer Dennis C. Flanagan, working with Norton and Shainberg, conducted field tests to examine how effective both gypsum and PAM could be at controlling soil loss on a steep and erodible silt loam soil. They tested surface applications of 2.2 tons per acre of gypsiferous byproduct from the Purdue University power plant in West Lafayette, Indiana, as well as a liquid solution of 18 pounds per acre of PAM sprayed on the soil and allowed to dry.

They found that the byproduct improved infiltration and could potentially reduce runoff and erosion problems on similar U.S. soils. The PAM surface treatment was very effective at controlling rill erosion, even for water inflows up to 16 gallons per minute per rill.

"PAM is a polymer produced from petrochemicals," says Stott. Efforts are under way with ARS researchers at the National Center for Agricultural Utilization Research in Peoria, Illinois, to develop a cheaper, starchbased copolymer.

Stott and ARS soil scientist Rodrick D. Lentz at Kimberly, Idaho, have tested many commercial synthetic PAM forms to pinpoint desirable characteristics. So far, they've found some types of PAM materials work better than others to reduce crusting, increase water infiltration, and promote seedling emergence.

NSERL lab experiments in 1992 showed that gypsum byproducts tested on three soils, using simulated rainfall, produced some valuable results. A byproduct of almost pure gypsum from a special coal-burning technique in power plants increased water infiltration and reduced soil loss by about one-fourth. A type of gypsum left over from fertilizer manufacturing did almost as well in reducing soil loss between rows.

Other related work at NSERL includes the blending of several byproducts like fly ash and organicrich industrial sludge. This appears



Samples of runoff water examined by soil scientist Darrell Norton were collected from an experimental plot in farmer Ralph Wood's gypsum-treated cornfield in Carlisle, Indiana.

very promising, says Norton, in producing a high-organic-matter, high-nitrogen, and high-phosphorus, soil-like material that is environmentally friendly.

This work has been done cooperatively with Purdue researchers and has received funding from several Indiana sources—the Eli Lilly Company, Lafayette; Purdue University power plant, West Lafayette; Amax Coal Company, Brazil; and the Indiana Department of Commerce, Indianapolis.

Now that Norton and NSERL scientists have documented some of the chemical, physical, and biological processes that occur on soils that have gypsum applied, they are currently studying the effects on crop yields.

Cooperating farmers report encouraging results. In one of over 50,000 acres of field tests, Ken Curtis of Prairie City, Illinois, used highpurity gypsum, a scrubber byproduct from a coal-fired unit of City Water, Light, and Power of Springfield, Illinois. He applied 3 tons of gypsum per acre to a 20-acre field of no-till soybeans, randomly applying various amounts.

"Treated soybeans yielded 63 bushels per acre—4 bushels more than the nongypsum control. I didn't expect that much response so quickly," says Curtis.

Norton plans to expand the test acreage to further assess benefits of gypsum on wheat, corn, and soybeans in several eastern states.—By Hank Becker, ARS.

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Adding a tracer dye enables graduate student Katerina Dontsova to measure the velocity of water flowing across an experimental plot.